Chlorine Gas Decision Tool

USERS' GUIDE

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CHLORINE GAS DECISION TOOL
FOR WATER AND WASTEWATER UTILITIES
Department of Homeland Security
March 2006

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Purpose and Acknowledgements

PURPOSE

The Chlorine Gas Decision Tool provides water and wastewater utilities with the means to conduct a simple assessment of alternatives to chlorine gas disinfection. The U.S. Department of Homeland Security's (DHS) Science and Technology Directorate, Advanced Research Projects Agency contracted with the National Association of Clean Water Agencies (NACWA) to develop the tool in an effort to encourage water and wastewater utilities currently using chlorine gas for disinfection to consider alternatives. Water and wastewater utilities may voluntarily submit the results of this assessment to assist the Department in its efforts to develop a better understanding of this sector. Details on this voluntary submittal of the final reports generated from the Decision Tool are contained in the Report Template section of this Users' Guide (p. 12).

ACKNOWLEDGEMENTS

Special thanks and appreciation are due to NACWA, its Officers, Board of Directors and staff for their leadership and commitment to this substantial undertaking, and the Chlorine Gas Decision Tool project team at CH2MHill, Inc. Thanks are also due to the water and wastewater industry leaders who donated their time and expertise to this effort.

Special thanks to the following individuals for the commitment to this effort:

Robert C. Steidel, City of Richmond, VA
David Pickard, City of Tampa, FL
William Moore, Metropolitan Council Environmental Services, St. Paul, MN
Salome Freud, New York City Department of Environmental Protection, NY
Madeline Goddard, City of Phoenix, AZ
Grace Chan, Sanitation Districts of Los Angeles County, Whittier, CA
Patrick Kwok, City of San Jose, CA
David Snyder, Sanitation Districts of Los Angeles County, Whittier, CA
Ronald Garner, City of San Jose, CA

Guide for Using the Chlorine Gas Decision Tool

Introduction and Background

Wastewater and drinking water utilities have safely and effectively used gaseous chlorine and sulfur dioxide for disinfection and wastewater dechlorination respectively for decades. While various regulatory programs have placed numerous restrictions on the uses of these chemicals, recent focus on the possibility of a terrorist attack at a wastewater or drinking water facility, has underscored the potential hazard these chemicals present. If released into the atmosphere, chlorine and sulfur dioxide have the potential to pose a hazard for utility employees and the public surrounding the affected facilities. This Chlorine Gas Decision Tool (Tool) was developed to assist wastewater and drinking water utilities who wish to evaluate alternative methods for disinfection.

Wastewater and drinking water utility managers considering alternatives to gaseous chlorine can use the Tool to compare the advantages, disadvantages and costs of each alternative, with the goal of determining which option best meets their particular utility's needs. Cost criteria including capital costs, operations and maintenance (O&M) costs, and life cycle costs for the alternatives are evaluated by the Tool. Also included are comparisons of the non-monetary factors critical to the evaluation and selection of a disinfection technology. These non-monetary factors are used by the Tool to perform a benefit to cost analysis.

The Tool has the capability to assess the following alternatives:

- Adding an emergency gas scrubber system to serve the existing gaseous chlorine system. If the system uses sulfur dioxide for dechlorination, adding a scrubber system for the sulfur dioxide is also evaluated. If the existing gas chemical systems are not enclosed, the cost of enclosing the existing systems in a building will be estimated.
- Converting the existing disinfection system to use purchased sodium hypochlorite. In addition, if the system uses gaseous sulfur dioxide for dechlorination, converting the existing dechlorination system to purchased sodium bisulfite.
- Converting the existing disinfection system to onsite generation of sodium hypochlorite. In addition, if the system uses gaseous sulfur dioxide for dechlorination, converting the existing dechlorination system to purchased sodium bisulfite.
- Converting the existing disinfection system to an ultraviolet light disinfection system and for water treatment the use of sodium hypochlorite for a secondary disinfectant.
- Utilizing ozone as the primary disinfectant and sodium hypochlorite as the secondary (water treatment only).

Overview of the Tool's Capabilities

The Chlorine Gas Decision Tool consists of several Microsoft Word® and Excel® files specific to either wastewater or drinking water evaluations. The Tool can be used to develop order-of-magnitude cost estimates to compare the costs of alternatives. The Tool ranks non-monetary considerations critical to the evaluation and selection of a disinfection technology (e.g., process reliability and worker safety) by assigning a relative value for each criteria and alternative, and then uses these rankings to calculate a non-monetary criteria benefit score. Results of the cost evaluation, non-monetary considerations, and benefit/cost ratios are presented graphically.

The Tool also provides a report template that will allow a utility to document its findings in a consistent manner that can be presented to others for review and consideration. The report template is

designed to be customized by each utility to produce a final report that describes each alternative, the advantages and disadvantages of the alternatives, and presents the estimated costs of implementing each alternative. The report template incorporates the non-monetary criteria score and the cost estimates from the Excel spreadsheets.

The Tool is intended to provide a recommended alternative that the utility may wish to explore further through a specific feasibility and cost analysis. It is not recommended that a utility implement an alternative based solely on the recommendations of this Tool.

What Staff Should be Involved?

Utilities that decide to use the Tool are encouraged to establish a team of staff members representing a wide range of utility perspectives that will be responsible for ranking criteria and providing the necessary utility-specific inputs. Involving staff who are familiar with operations, maintenance, and management issues will help provide a balanced view of the issues that must be considered in evaluating alternatives.

Use of the Tool

The Tool is comprised of two items – an Excel spreadsheet and one Word report template. Two different sets of files are available on this CD – one set designed for use by drinking water facilities and one for wastewater facilities. The name of the Excel spreadsheet file for wastewater is *Wastewater Decision Tool* and the Excel file for water is *Water Decision Tool*. The spreadsheets, each containing several 'tabs', are the key element of the Tool.

The Tool spreadsheet (whether wastewater or drinking water) contains a cost estimating module where data specific for the plant are entered, such as chlorine demand, chlorine cost, and power costs. The spreadsheet uses these data to determine capital, operating, and life cycle costs estimates for each alternative. The spreadsheet also permits the utility to rank non-monetary considerations using a numerical scale. Each of the non-monetary considerations is weighted to allow the importance of each consideration to be tailored to the utility's needs. These rankings are then tallied and displayed graphically for each alternative. The spreadsheet then uses the cost information and the rankings to calculate a cost/benefit ratio comparison.

The output tables of the monetary and non-monetary spreadsheet 'tabs' can then be inserted ("cut and pasted") into the report template to show the results of the evaluations and create a customized report. The spreadsheet and the report template are discussed in more detail in the following sections.

The 'tabs' or individual sheets within the spreadsheet file are color coded as follows:

Yellow = Inputs required by the user on this sheet. Inputs required for all cells that are highlighted in yellow.

Blue = Outputs of tables or graphs that will be cut and pasted into the report template

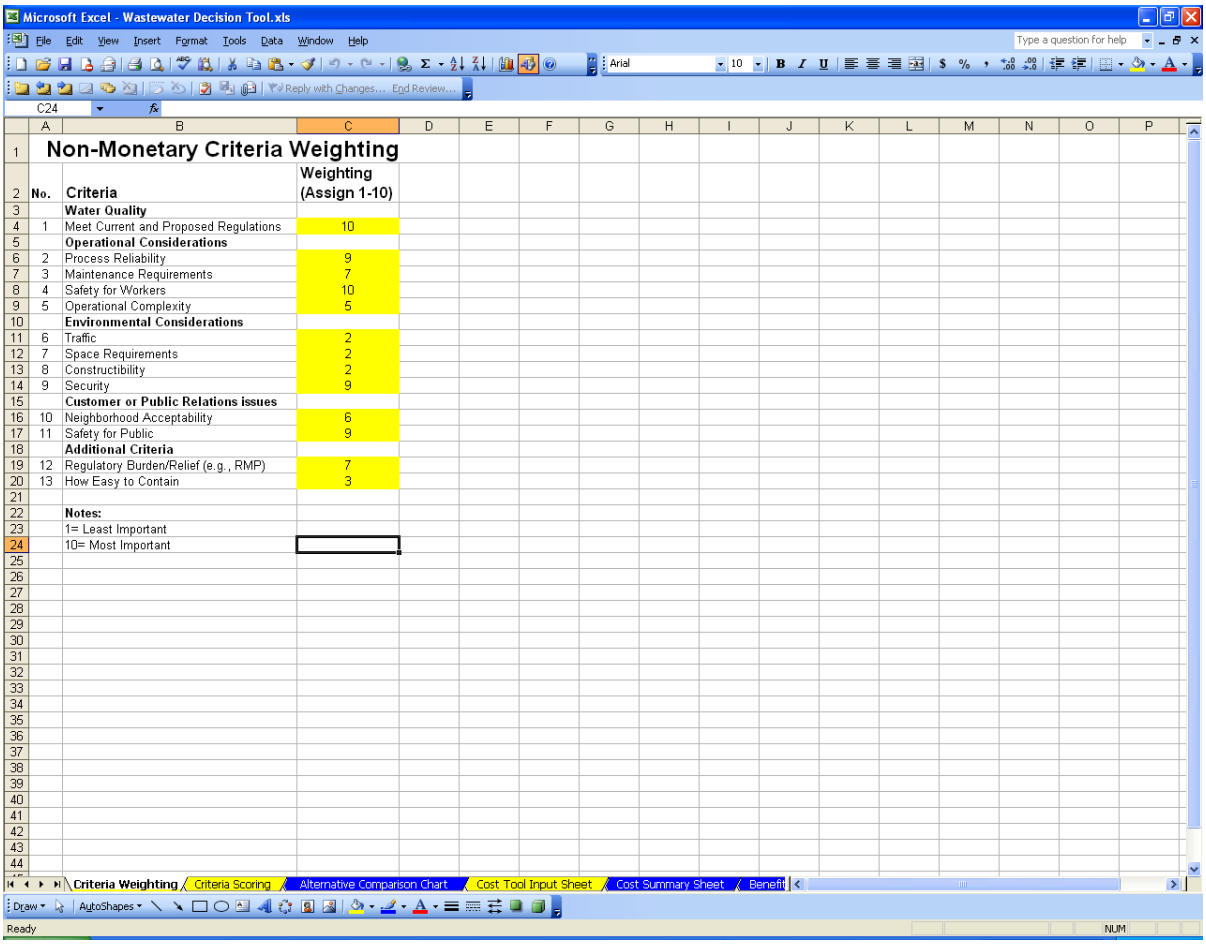
(Note: There are several hidden tabs that perform calculations and cannot be accessed by the user)

Non-Monetary Ranking

This part of the Excel spreadsheet is used to evaluate and rank non-monetary considerations for each alternative. Before completing the non-monetary inputs, the user should read the material presented in the report template regarding each process including the process description and the advantages and disadvantages of each process. This information can be used as guidance to becoming familiar with the alternatives to help complete the non-monetary rankings.

The non-monetary rankings are accomplished as follows:

1. Open the appropriate Excel file (wastewater or water) and go to the "Criteria Weighting" sheet which is shown below.

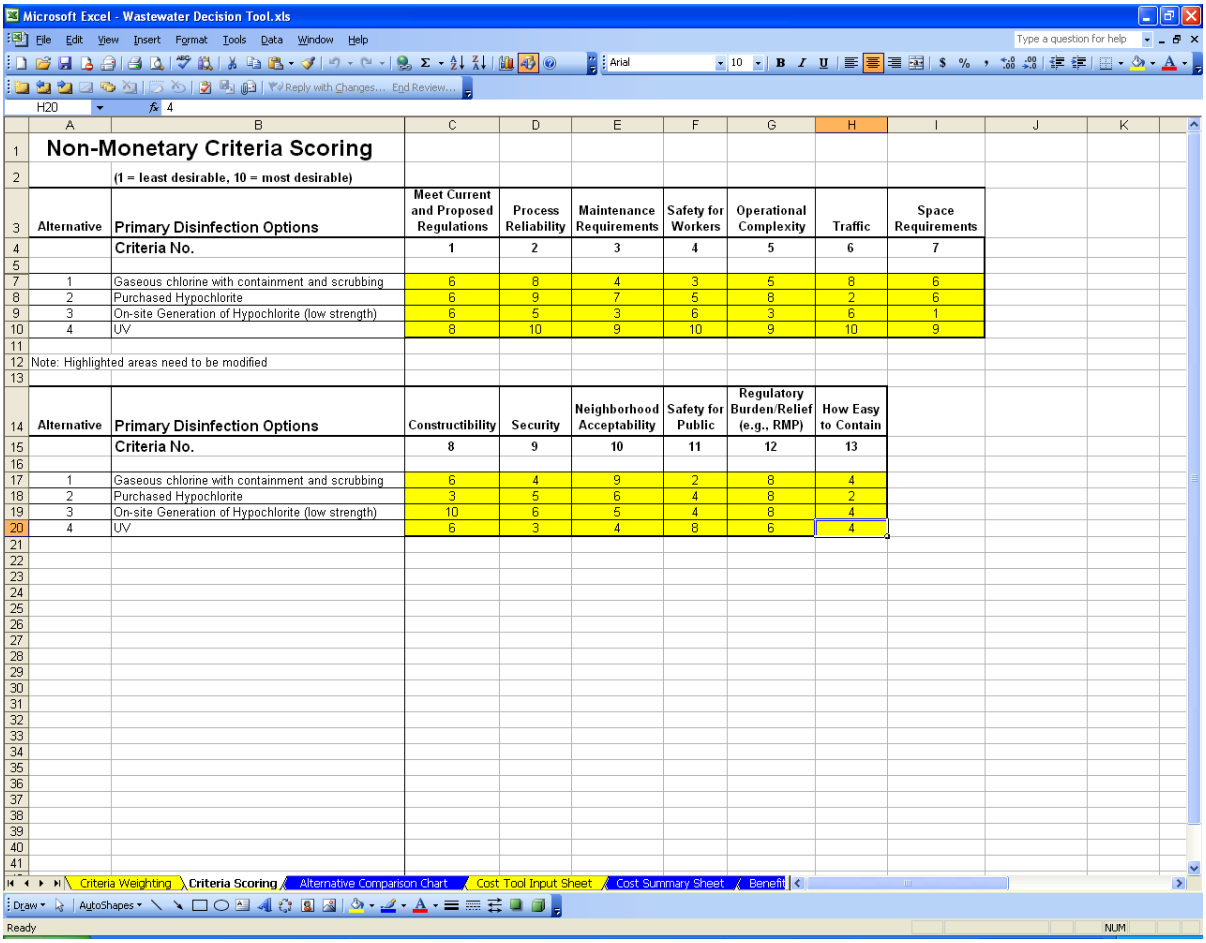


When you open the Criteria Weighting sheet, all of cells highlighted in yellow will have an input of "1" which needs to be changed. To account for the importance of each criterion to your utility, each of the non-monetary criteria must be assigned a weighting using a scale of one to ten with ten being most important and one the least important to your utility.

> Example: For a utility that is located in a residential neighborhood with a plant access road that passes directly through that neighborhood, the "Traffic" criteria would probably be given a relatively high weighting value because of the potential increase in truck traffic through the neighborhood to deliver purchased sodium hypochlorite. Conversely, for a plant located in an industrial area with direct access from a highway, the Traffic criteria would be assigned a lower weighting. Another example is for a utility that has a highly trained operating staff who is accustomed to operating complex systems, the "Operational Complexity" criteria would be given a relatively low weighting because the utility is confident that the operators are capable of effectively operating a complex system.

The information regarding each alternative presented in the report template should be reviewed to help determine appropriate values for the non-monetary criteria.

2. On the "Criteria Scoring" sheet in the cells highlighted in yellow, enter a score for each criterion for each alternative. The Criteria Scoring sheet is shown below.

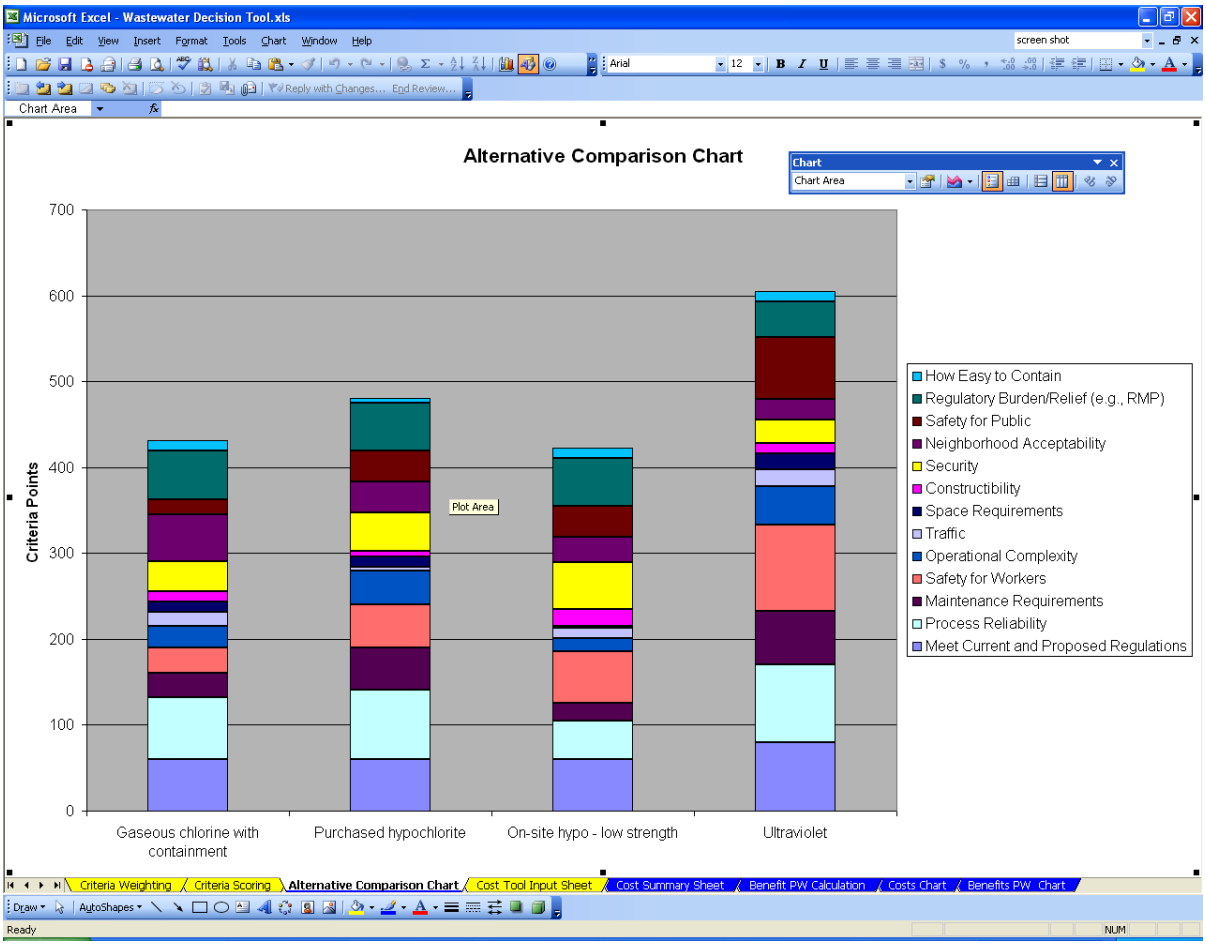


A scale of one to ten should be used with a score of ten indicating the most desirable and one being the least desirable.

> Example: For a gaseous chlorine system, the "Safety for Workers" criteria would receive a relatively low score because of the potential toxic gas workers could be exposed to in the event of a chlorine leak. The UV alternative on the other hand would receive a much higher score because of the very limited hazards for workers associated with a UV system.

Again, the information regarding each alternative presented in the report template should be reviewed to help determine appropriate values for the non-monetary criteria.

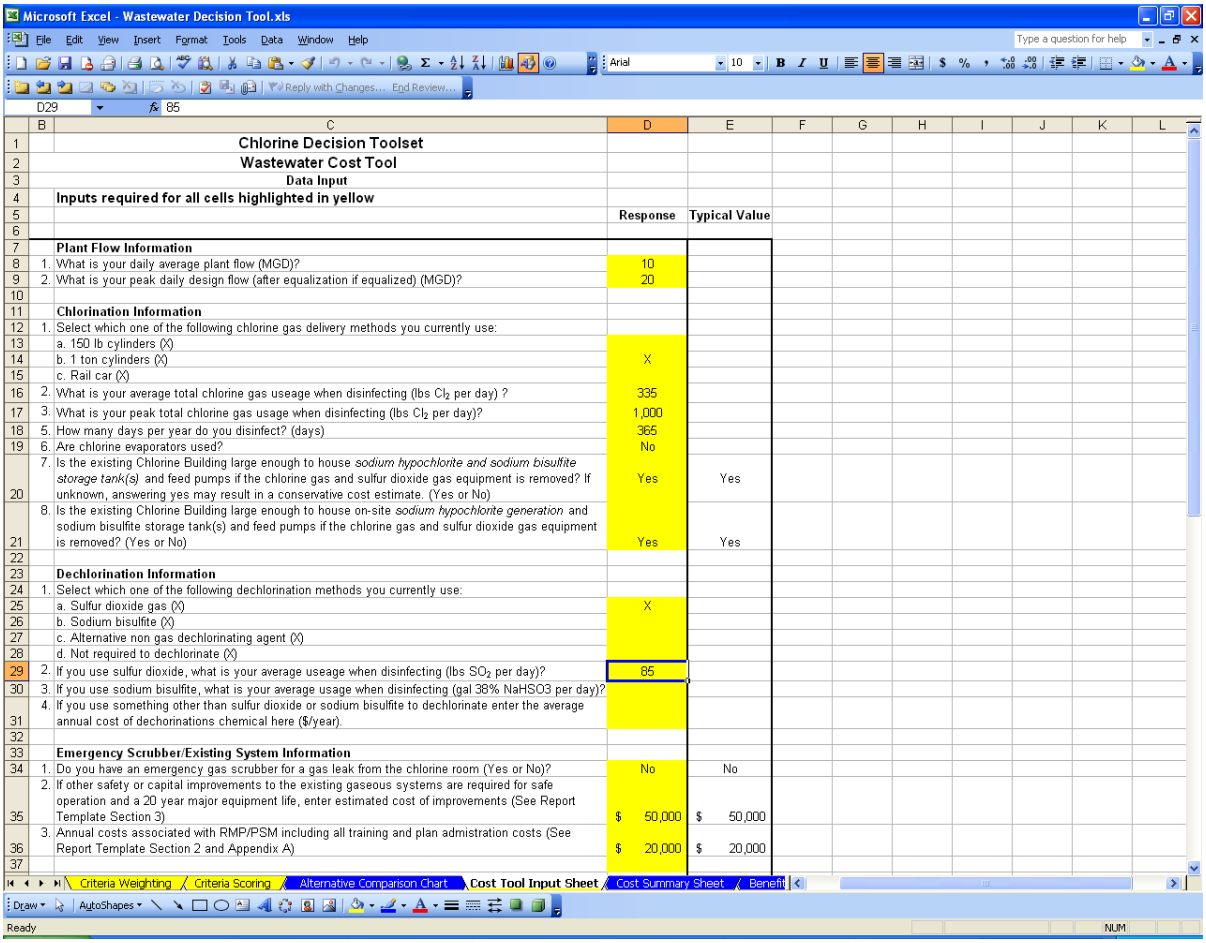
3. After entering the criteria weighting and scoring, the spreadsheet then calculates the non-monetary criteria scores and displays the results graphically in the "Alternatives Comparison Chart." An example of one of these graphical outputs is shown below.



Cost Estimating

The cost estimating tool within the spreadsheet is used to estimate capital, O & M, and lifecycle costs for each alternative as follows:

1. Enter values in the "Cost Tool Input Sheet" in the cells that are highlighted in yellow. Some default and 'typical' values for certain costs are also provided, but users are encouraged to use utility-specific information. The Cost Tool Input Sheet is shown below.



Microsoft Excel - Wastewater Decision Tool.xls

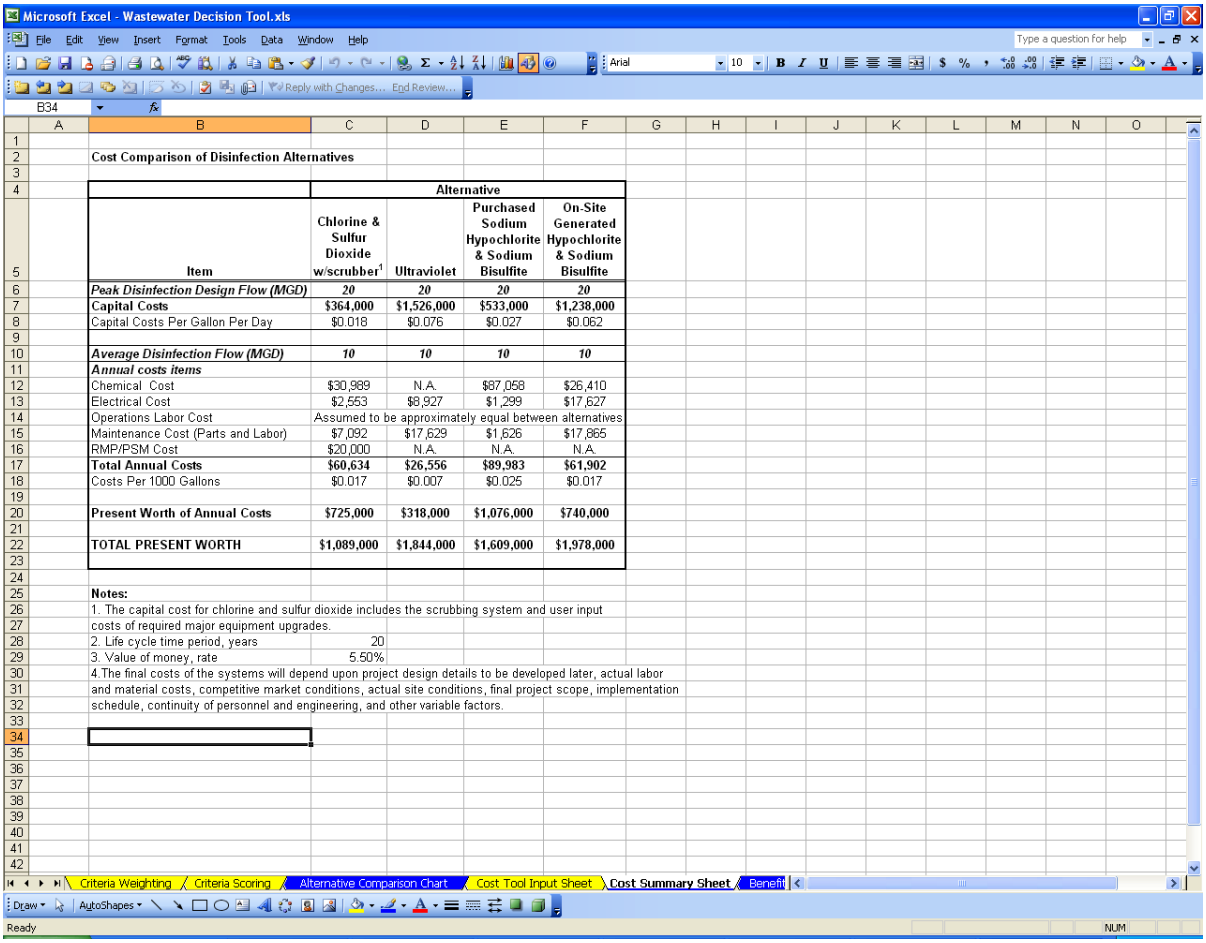
	B	C	D	E
1		**Chlorine Decision Toolset**		
2		**Wastewater Cost Tool**		
3		**Data Input**		
4		**Inputs required for all cells highlighted in yellow**		
5			**Response**	**Typical Value**
6				
7		**Plant Flow Information**		
8	1.	What is your daily average plant flow (MGD)?	10	
9	2.	What is your peak daily design flow (after equalization if equalized) (MGD)?	20	
10				
11		**Chlorination Information**		
12	1.	Select which one of the following chlorine gas delivery methods you currently use:		
13		a. 150 lb cylinders (X)		
14		b. 1 ton cylinders (X)	X	
15		c. Rail car (X)		
16	2.	What is your average total chlorine gas useage when disinfecting (lbs Cl_2 per day) ?	335	
17	3.	What is your peak total chlorine gas usage when disinfecting (lbs Cl_2 per day)?	1,000	
18	5.	How many days per year do you disinfect? (days)	365	
19	6.	Are chlorine evaporators used?	No	
20	7.	Is the existing Chlorine Building large enough to house *sodium hypochlorite and sodium bisulfite storage tank(s)* and feed pumps if the chlorine gas and sulfur dioxide gas equipment is removed? If unknown, answering yes may result in a conservative cost estimate. (Yes or No)	Yes	Yes
21	8.	Is the existing Chlorine Building large enough to house on-site *sodium hypochlorite generation* and sodium bisulfite storage tank(s) and feed pumps if the chlorine gas and sulfur dioxide gas equipment is removed? (Yes or No)	Yes	Yes
22				
23		**Dechlorination Information**		
24	1.	Select which one of the following dechlorination methods you currently use:		
25		a. Sulfur dioxide gas (X)	X	
26		b. Sodium bisulfite (X)		
27		c. Alternative non gas dechlorinating agent (X)		
28		d. Not required to dechlorinate (X)		
29	2.	If you use sulfur dioxide, what is your average useage when disinfecting (lbs SO_2 per day)?	85	
30	3.	If you use sodium bisulfite, what is your average usage when disinfecting (gal 38% NaHSO3 per day)?		
31	4.	If you use something other than sulfur dioxide or sodium bisulfite to dechlorinate enter the average annual cost of dechorinations chemical here ($/year).		
32				
33		**Emergency Scrubber/Existing System Information**		
34	1.	Do you have an emergency gas scrubber for a gas leak from the chlorine room (Yes or No)?	No	No
35	2.	If other safety or capital improvements to the existing gaseous systems are required for safe operation and a 20 year major equipment life, enter estimated cost of improvements (See Report Template Section 3)	$ 50,000	$ 50,000
36	3.	Annual costs associated with RMP/PSM including all training and plan admistration costs (See Report Template Section 2 and Appendix A)	$ 20,000	$ 20,000
37				

Criteria Weighting | Criteria Scoring | Alternative Comparison Chart | Cost Tool Input Sheet | Cost Summary Sheet | Benefit

Ready

It is recommended that wherever possible actual utility-specific data be used. However, if data are not available, the default values shown on the Input Sheet tab can be used. Completing this sheet will require that several pieces of data be gathered before the inputs can be made, such as chlorine usage, cost of chlorine, and plant flow rates.

2. Once the costs inputs have been made, the spreadsheet calculates an estimated order of magnitude capital, O & M, and present worth value for each alternative on the "Cost Summary Sheet" tab. This sheet is shown below.



Microsoft Excel - Wastewater Decision Tool.xls

Cost Comparison of Disinfection Alternatives

Item	Alternative			
	Chlorine & Sulfur Dioxide w/scrubber[1]	Ultraviolet	Purchased Sodium Hypochlorite & Sodium Bisulfite	On-Site Generated Hypochlorite & Sodium Bisulfite
Peak Disinfection Design Flow (MGD)	***20***	***20***	***20***	***20***
Capital Costs	**$364,000**	**$1,526,000**	**$533,000**	**$1,238,000**
Capital Costs Per Gallon Per Day	$0.018	$0.076	$0.027	$0.062
Average Disinfection Flow (MGD)	***10***	***10***	***10***	***10***
Annual costs items				
Chemical Cost	$30,989	N.A.	$87,058	$26,410
Electrical Cost	$2,553	$8,927	$1,299	$17,627
Operations Labor Cost	Assumed to be approximately equal between alternatives			
Maintenance Cost (Parts and Labor)	$7,092	$17,629	$1,626	$17,865
RMP/PSM Cost	$20,000	N.A.	N.A.	N.A.
Total Annual Costs	**$60,634**	**$26,556**	**$89,983**	**$61,902**
Costs Per 1000 Gallons	$0.017	$0.007	$0.025	$0.017
Present Worth of Annual Costs	**$725,000**	**$318,000**	**$1,076,000**	**$740,000**
TOTAL PRESENT WORTH	**$1,089,000**	**$1,844,000**	**$1,609,000**	**$1,978,000**

Notes:

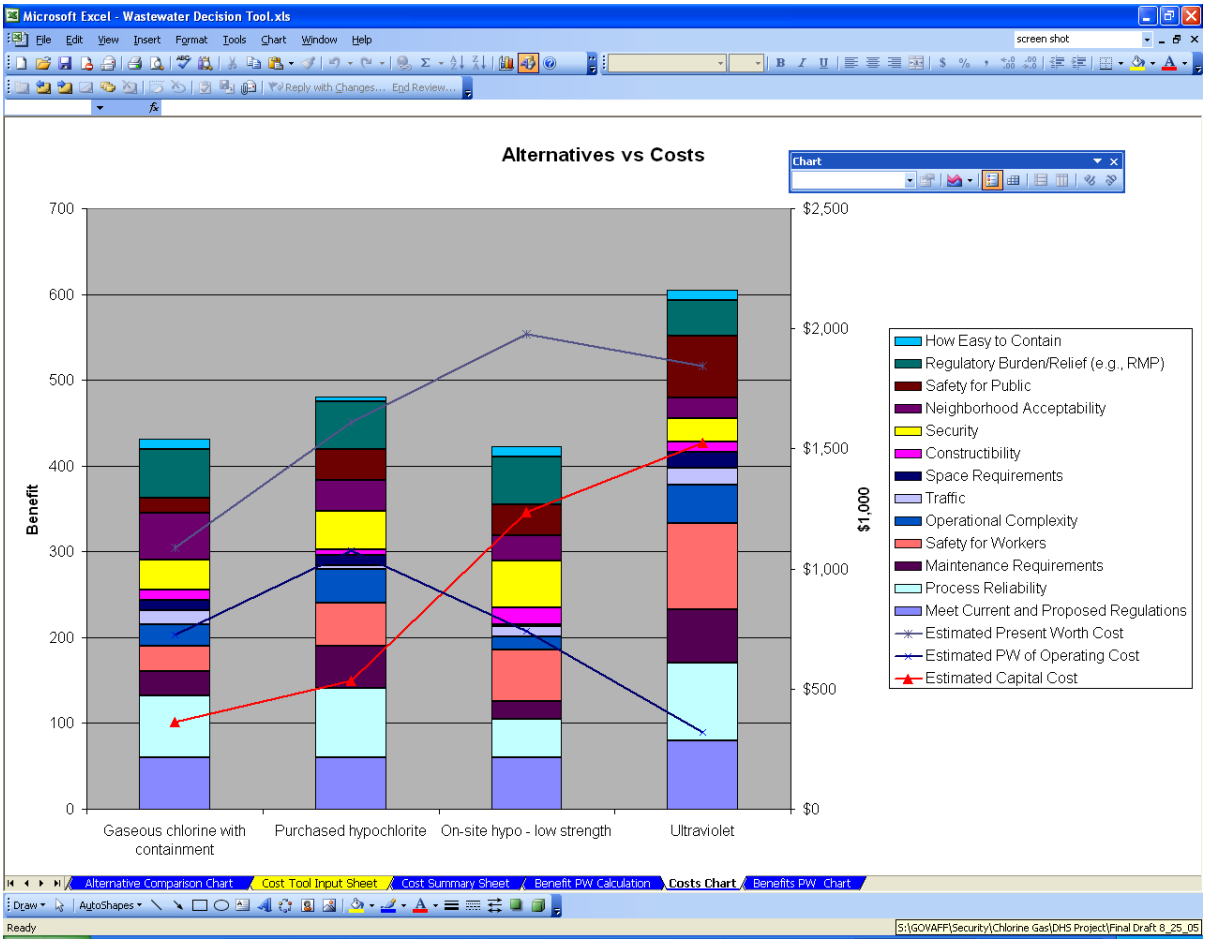
1. The capital cost for chlorine and sulfur dioxide includes the scrubbing system and user input costs of required major equipment upgrades.
2. Life cycle time period, years: 20
3. Value of money, rate: 5.50%
4. The final costs of the systems will depend upon project design details to be developed later, actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors.

Criteria Weighting | Criteria Scoring | Alternative Comparison Chart | Cost Tool Input Sheet | Cost Summary Sheet | Benefit

Ready

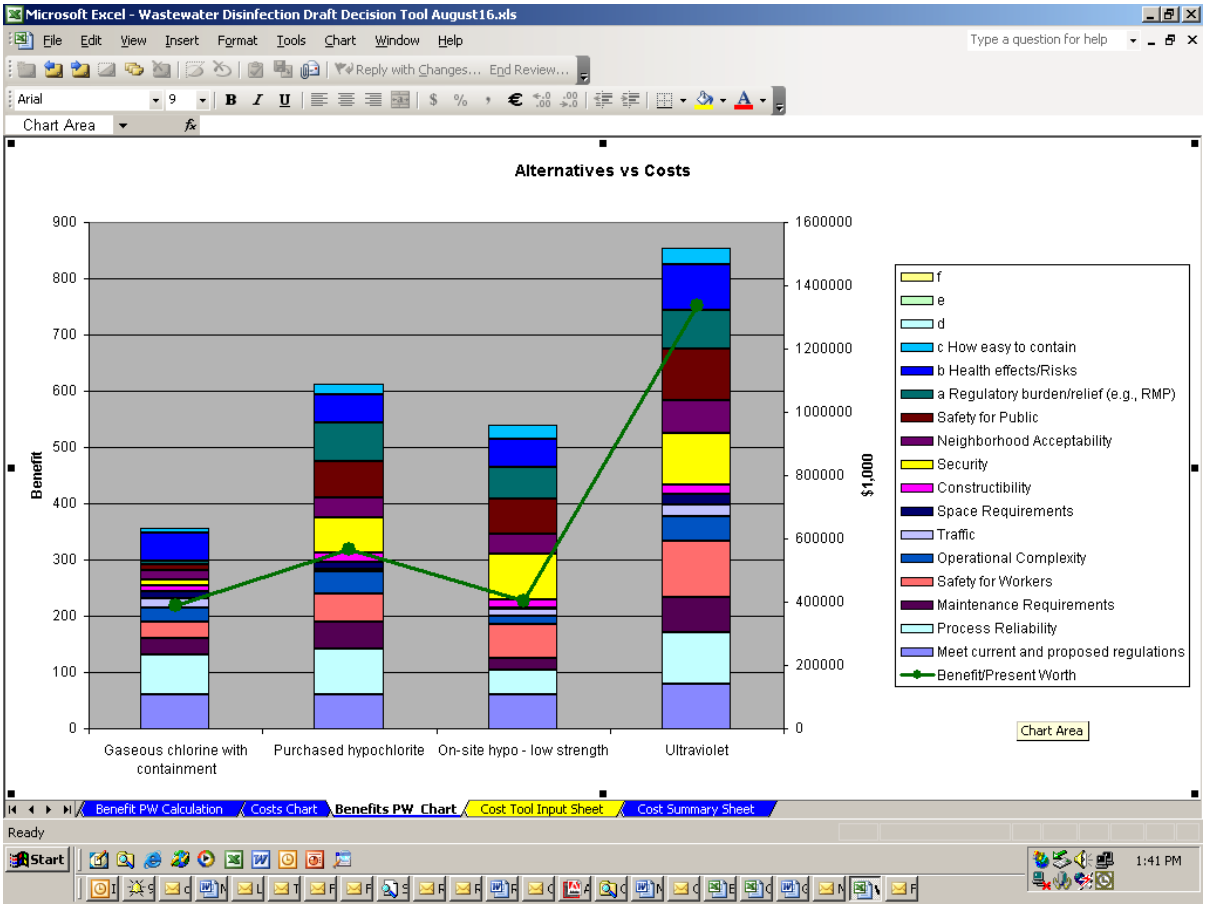
These cost outputs are estimated based on a series of "cost curves". The curves were developed by a regression analysis of actual construction data from completed projects and cost estimates for conceptual projects of various sizes. The estimated capital costs are for construction only and do not include costs for design, services during construction, and utility costs for project administration. The cost estimates are intended to be used primarily to make a relative comparison of the alternatives. The accuracy of the cost estimates is intended to be at best +50%/-30% and the actual costs of the project will vary depending upon several factors such as project location, competition level among contractors and vendors and local site conditions. If the default costs are used, the accuracy of these numbers for a particular agency may be further skewed.

The "Costs Chart" shown below provides a graphical comparison of estimated order of magnitude capital, O & M, and present worth value for each alternative



Selection of Alternative

The graph shown below, detailing the ratio of non-monetary benefits to present worth, will be generated by the decision tool and is the primary piece of information that should be used to select a potential alternative to chlorine gas. The alternative(s) with the highest benefit to present worth ratio is the most desirable alternative. The height of the colored bars for each alternative can be used to graphically provide insight into how the non-monetary benefit score was derived. For example, UV, in the graph below, had the highest score primarily because of superior safety for workers, regulator relief and system reliability. It is recommended that a more detailed cost estimate of the alternative with the highest benefit to present worth ratio be developed before proceeding with implementing the alternative.



Report Template

The files *Wastewater Report Template* and *Water Report Template* are Word documents that can serve as templates for preparing a report to outline the alternatives considered and the results of the monetary and non-monetary evaluation (examples of completed reports are also provided for your reference). The yellow highlighted areas in the report template files indicate where the user must "fill in the blanks" in order to customize the report for their agency.

The user must also insert or “cut and paste” several tables from the cost estimating and non-monetary ranking spreadsheets into the report template, where indicated, to complete the report. A description of which tables must be copied and where they must be inserted is included within the template. When pasting Excel tables into the report template, it is generally best to use the “paste special” command and paste the tables as a “picture”. Doing this will keep the pasted table in the report template within the margins of the document.

The completed report will serve as a stand alone document that can be distributed to the appropriate decision makers within your utility for review and consideration. If the results of using the Tool show that replacing your existing gas systems with an alternative appears promising, it is recommended that a more detailed estimate of the alternative costs be developed before proceeding with implementing the alternative.

This report template can also be submitted to DHS on a voluntary basis by emailing the completed report to *ChlorineDecisionTool@dhs.gov*. These voluntary submissions will be used by DHS to develop a better understanding of this sector and will be controlled accordingly using appropriate handling protocols. All reports emailed to this address should be marked clearly in the header and footer of the document "For Official Use Only (FOUO)/ Protected Critical Infrastructure Information (PCII)”.